Synthesis and Characterization of Dy^{3+} Doped Phosphate Glasses

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Abstract
Dysprosium doped phosphate glasses having composition $50P_2O_5$ - $10Al_2O_3$ - (20-x) Na_2O - 20CaO - xDy_2O_3 with x varying from 1 to 5 mol % were prepared using the conventional melt quench technique. The amorphous nature of glasses was confirmed from the XRD spectra of prepared glass series. The UV-Visible absorption spectra in the range 200-1100 nm were recorded using UV -Visible spectrophotometer. Absorption spectra consist of eight absorption peaks corresponding to the transitions from $^6H^{15/2}$ ground state to various possible excited states.

Keywords
Phosphate Glass, Melt Quench, XRD, Absorption Spectra

I. Introduction

These days rare earth doped phosphate glasses are being extensively studied due to their high technological importance and their applications in solid state lasers and optical fibres. These glasses have high luminescence efficiency and they lack thermal lensing effects. When compared with borate and silicate glasses these glasses have distinctive optical properties such as large infrared transmission window, high gain density, low up-conversion and wide bandwidth emission spectra [1-4]. The high gain density in phosphate glasses is due to high solubility of rare earth ions in phosphate network [5]. Among the different rare earth ions dysprosium doped glasses have been considered as the promising materials for 1.3µm emission. Also incorporation of Al2O3 into phosphate glass network also increases the cross-linking between PO4 tetrahedra in the glasses which enhances the chemical durability of phosphate glasses [6].

II. Experimental Procedure

Dy_2O_3 doped phosphate glasses with composition $50P_2O_5$-$10Al_2O_3$-(20-x) Na_2O-20CaO-xDy_2O_3 with x having values 1,2,3,4 and 5 mole% resp. were prepared using the melt quench technique. All the chemicals were weighed and were mixed in a ball mill using zirconium balls for 24 hours to obtain consistency in the batch. The batch was then placed in an alumina crucible which was further kept in an electric furnace set at temperature ranging from 1200 to 1250^0 C. The melt was kept at this temperature for 1 hour to obtain a homogeneous mixture. This melt was then poured onto a preheated steel plate maintained at suitable temperature. The resultant product was transparent and bubble free glass. This glass was further annealed at 400^{0}C for 24 hours to remove any internal stress or strain. Table 1 shows the nominal composition in mol % of the prepared glass samples.

XRD spectra of powdered glass samples were recorded using XRD 7000 Shimadzu X- Ray Diffractometer at the scanning rate of 2^0 per minute in the range of 20-80^0 . UV Visible absorption spectra of polished glass samples of thickness 1.2 mm were recorded using double beam spectrophotometer in the range 200-1100 nm to study various transitions.

Table 1: Shows the Nominal Composition in mol % of the prepared Glass Samples

P_2O_5	Al_2O_3	Na_2O	CaO	Dy_2O_3 (x)	T_m (^{0}C)
50	10	19	20	1	1200
50	10	18	20	2	1250
50	10	17	20	3	1250
50	10	16	20	4	1250
50	10	15	20	5	1250

II. Result and Discussion

A. XRD Spectra

Fig. 1 shows the XRD spectra of prepared glass samples at room temperature. Absence of any sharp peak in the spectra confirmed the amorphous nature of prepared glasses. A broad hump near 22^0 which is characteristic for glasses is also observed for all the prepared glasses.

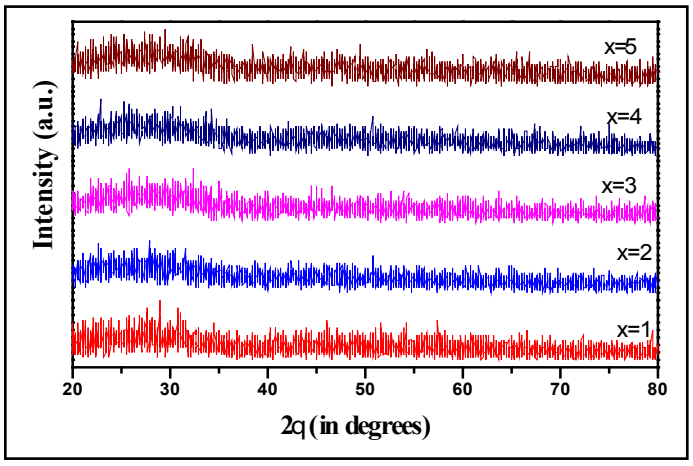

Fig. 1: XRD Spectra of Prepared Glass Samples

B. Optical Absorption Spectra

Fig. 2 shows the UV-Visible absorption spectra of prepared glass samples in 300-1100 nm range.

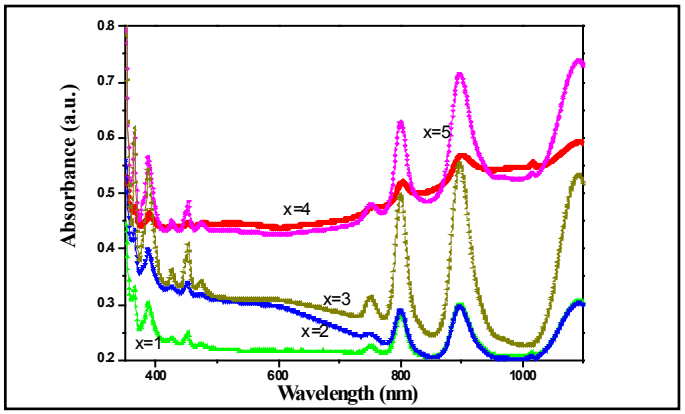

Fig. 2: UV Visible Absorption Spectra of $50P_2O_5$-$10Al_2O_3$-(20-x) Na_2O-20CaO-x Dy_2O_3 Glasses

Seven prominent peaks are observed in the spectra and the intensity of these peaks increases with increase in the concentration of Dy_2O_3. The absorption band assignment has been done on the basis of energy level positions.

From fig. 2 it is clear that the levels $^6F_{3/2}$, $^6F_{5/2}$, $^6F_{7/2}$, $^6F_{9/2}$ are very well resolved and have sharp peaks in the range from 750 to 1100 nm. The higher energy levels corresponding to bands at 4F9/2, 4I9/2, 6I15/2 have less intense peaks in the range 380-500 nm. Table 2 shows different transitions corresponding to different wavelengths [7].

Table 2: Shows Different Transitions Corresponding to Different Wavelengths

Transition	Wavelength
$^4F_{9/2} \rightarrow {}^6H_{15/2}$	386
$^4F_{9/2} \rightarrow {}^6H_{13/2}$	452
$^4F_{9/2} \rightarrow {}^6H_{11/2}$	476
$^4F_{9/2} \rightarrow {}^6H_{9/2}$	756
$^4I_{13/2} \rightarrow {}^6F_{5/2}$	804
$^4I_{15/2} \rightarrow {}^6F_{7/2}$	903

IV. Conclusion

The prepared glasses were bubble free and transparent in nature. The amorphous nature of the glasses was confirmed from the XRD spectra. Seven different peaks were observed in the UV- Visible absorption spectra for all the glasses which correspond to different transitions corresponding to doping of Dy2O3. It is observed that the intensity of these peaks increases considerably with increase in the Dy2O3concentration.

References

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